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## CHARACTERS AND RESTORATION OF THE SAUROPOD GENUS CAMARASAURUS COPE.<sup>1</sup>

FROM TYPE MATERIAL IN THE COPE COLLECTION IN THE AMERICAN  
MUSEUM OF NATURAL HISTORY.

(PLATE I.)

By HENRY FAIRFIELD OSBORN AND CHARLES CRAIG MOOK.

In 1902 the Cope Collection of Fossil Reptiles was presented to The American Museum of Natural History by President Morris K. Jesup. It included all of Cope's types and other dinosaur material of Morrison age from the vicinity of Canyon City, Colorado. Several of these types antedated in definition Marsh's types from beds of similar age. Cope's references were full but accompanied by few figures; Marsh's came later and were adequately illustrated. Marsh also issued in the publications of the United States Geological Survey two more or less complete summaries of the characters of these animals, which were fully illustrated and widely distributed. Consequently they became well established in the literature, while Cope's are still unrecognized and imperfectly known. Our object has been to describe and determine as fully as possible Cope's types, especially of the Sauropoda, the most important of which is that of *Camarasaurus*. This generic name antedates *Morosaurus* Marsh, with which it is considered congeneric, by about one year.

The fugitive descriptions and determinations by Cope, Osborn, Riggs and Mook may now be replaced by thorough descriptions and illustrations, in which the characters of the genus *Camarasaurus* are determined in great detail, so far as the nature of the material will permit. All the type material, including the types of six genera and eleven species, has been figured and these animals, practically unknown since their original mention forty years ago, have now been brought to light.

<sup>1</sup> Partly printed in the *Proceedings of the Palaeontological Society, Bulletin of the Geological Society of America.*

## OCCURRENCE AND COLLECTING OF MATERIAL.

*Original Discovery and Collecting.*—In the spring of 1877 Mr. O. W. Lucas, superintendent of public schools in Canyon City, Colorado, discovered some large fossil bones, which he sent to Professor Edward D. Cope. The date of this discovery is not definitely known, but it appears to have been some time in March. From the first specimens which reached the Cope Museum in Philadelphia, Cope made his original description of *Camarasaurus* and founded the genus; this description was published August 23, 1877. The name *Camarasaurus*, or "chambered saurian," was given in reference to the cavernous nature of the centra of the cervical and dorsal vertebræ, in connection with the lateral cavities now known as pleurocoelia. After receiving the original bones, Cope employed collectors who gathered more material, all of which is now in the American Museum.

*Subsequent Collecting.*—The amount of material collected by Cope's parties was very large. It was not all prepared at once, but a considerable amount of it was cleaned up by Jacob Geismar under Professor Cope's direction. In 1877 a reconstruction of the skeleton of *Camarasaurus* was made by Dr. John A. Ryder, under the direction of Professor Cope. This reconstruction, the first ever made of a sauropod dinosaur, was natural size and embodied representations of the remains of a number of individuals; it was over fifty feet in length. It was exhibited at a meeting of The American Philosophical Society on December 21, 1877, and since has been exhibited a number of times at the American Museum (where it is now preserved) and elsewhere. A greatly reduced copy of it was published by Mook in 1914.<sup>2</sup>

After the collecting of the material which formed the basis of the above-mentioned reconstruction, Cope's collectors sent in more material. This collecting was continued until 1880.

*The Quarries.*—Unfortunately the quarry records of the Cope Canyon City material have been lost; no quarry diagrams are mentioned in any of Cope's descriptions, and it is unlikely that any were

<sup>2</sup> "Notes on *Camarasaurus* Cope," by Charles C. Mook, *Ann. New York Acad. Sci.*, Vol. XXIV., pp. 19-22, May 21, 1914, 1 fig.

made. Two large quarries are known to have existed and their location is known at the present time.

One large quarry is situated about 500 yards west to southwest of a small conical hill, locally known as the "Nipple," a considerable distance from the edge of the escarpment. This quarry is called Cope Quarry No. 1. Here the Morrison is capped by the Purgatoire sandstone and the quarry site is very definitely marked by a great excavation. The matrix is chiefly reddish to brownish, and *probably* most of the bones of a reddish color, collectively known as the red series, came from this quarry.

Another quarry is situated almost at the crest of the escarpment which forms the west boundary of Garden Park, and near the base of the "Nipple." It is not very definitely marked, but traces of the work of excavation by Cope's collectors and others mark its site. This quarry is called Cope Quarry No. 2. The matrix is largely grayish and it is likely that it furnished most of the bones which are known collectively as the yellow series, although this is not certain. Some of the matrix is neither gray nor yellow, and it is possible that certain of the yellow bones may have come from the other quarry. The value, therefore, of the color of the matrix, in determining the field association of the bones, is limited. Variation in color depends upon the condition of the iron oxide of the matrix, and probably also upon the original conditions of decay of the animal tissue. The quarry was reworked by Mr. J. B. Hatcher for the Carnegie Museum in 1901.

There may have been one more quarry in this vicinity which perhaps furnished some of the sauropod material, but the nature and the location of it are not known; indeed, the types of *Amphicælias altus* and *A. latus* may have come from this quarry, about which no reliable information is available. All three quarries are located a short distance north of the quarry worked by Mr. M. P. Felch, later known as the Marsh-Hatcher quarry, which yielded the genotypes *Diplodocus longus* Marsh and *Haplocanthosaurus priscus* Hatcher, also *H. utterbacki* Hatcher. The Marsh-Hatcher quarry was excavated at a lower geological level than the Cope quarries.

## PREPARATION AND RESEARCH IN THE AMERICAN MUSEUM.

*Acquisition.*—The Cope Collection of Fossil Reptiles had been examined in Philadelphia by Dr. W. D. Matthew and was transferred to the American Museum under his direction. The preparation of the material was made by Messrs. Kaison, Charles and Otto Falkenbach, Lang, Christman, Hoover, Brückner, Carr and Horne.

*Research in 1904.*—Doctor Matthew went over the material, under the direction of Professor Osborn, and catalogued and identified it so far as was possible with the aid of the records available, distinguishing the material obtained in the earlier collecting in 1877 by Superintendent Lucas from that obtained in the later collecting in 1880 under Mr. Ira H. Lucas. The bones of the earlier collection were given the number 5760, with variations according to their identification as individuals, such as 5760' and 5760''; the bones of the later collection were given the number 5761, with a modification into 5761-a for a presumably different individual than the rest of 5761. Subsequently Professor Osborn and Professor W. K. Gregory made a further study of the vertebræ and arranged them provisionally into series, using in addition to the previous records the color of the bones, those of the red series apparently having come from a different quarry than those of the yellow series. Most, if not all, of the red bones probably came from Cope Quarry No. 1, and most, if not all, of the yellow from Cope Quarry No. 2.

In connection with this work, which was carried on in 1904, Mr. Rudolph Weber, then artist of the Department of Vertebrate Palæontology, made line drawings of many of the vertebræ. In 1906 some wash drawings of the skull material were made by Mr. Erwin S. Christman. These illustrations were originally prepared for the United States Geological Survey Monograph on the Sauropoda, in course of preparation by Professor Osborn. The cost of preparation of these drawings was borne by the Survey.

*Research in 1912–1919.*—In 1912 work on the Cope Sauropoda material was renewed as part of the preparation of the Sauropoda Monograph, which was being prepared for the Survey by Professor Osborn. This work was undertaken by the present junior author under the direction of the senior author. The entire Cope Collection

of Sauropoda from Canyon City was studied, among other material, with the object of separating the vertebræ and limb bones referable to *Camarasaurus*, *Amphicælias* and the other Cope genera, and arranging them in series *similar in size, proportion and color*, as well as determining the characters of *Camarasaurus* and *Amphicælias* and the less known genera. To a considerable extent this work consisted in verification of the previous work by Doctor Matthew and Professor Gregory, in modification of their results, in a few cases, and in adding to them to meet the present needs.

This research has terminated in the arrangement of the vertebræ and ribs in *morphological series*, which may represent originally distinct individuals, or may not. The attempt was made to associate the bones of single individuals so far as practicable, but in many cases evidence for this was insufficient and in such cases an attempt was made to assemble series that would be reasonably constituted in a morphological sense. The arrangement of the bones in these series is as accurate as it could be made, in view of the distorted, sometimes incomplete and badly mixed character of the material. The pairing of the girdle and limb bones was similarly undertaken, though no attempt was made to pair the ribs. In a few cases it has been possible to determine the relation of some of the girdle and limb bones with the vertebræ, but in most cases the original association is still unknown, though their possible association is very evident.

*Carnivorous Dinosaur Material and Types.*—The type of *Epanterias amplexus* consists of bones of a large theropod. There are some ribs among those of *Camarasaurus* which certainly do not agree in characters with the majority of camarasaur ribs, and do resemble those of the Theropoda. There is also a theropodous femur. They may be provisionally referred to this form. It is possible, if not probable, that the types of *Tichosteus lucasanus* and *T. æquifacies*, also of *Sympyrophus musculosus*, may be referable to the Theropoda. Cope's types of *Lælaps trihedrodon*, *Brachyrophus altarkansanus* and *Hypsirophus discurus* were also collected at this locality. The first of these is certainly a theropod; the position of the second and of the third is uncertain.

*Characters of the Genus Camarasaurus.*—The results of the investigations described above include determinations of the generic

characters of *Camarasaurus* and *Amphicælias*, so far as these characters are determinable from the material in the collection. The genus *Camarasaurus* is characterized by massive proportions. Throughout the skeleton, with the single exception of the ischium, the bones are stoutly constructed.

*Synonymy of Camarasaurus Cope and Morosaurus Marsh.*—In 1898 the synonymy of *Morosaurus* Marsh with *Camarasaurus* Cope was suggested by Osborn;<sup>3</sup> in 1902 this view was favored by Riggs;<sup>4</sup> in 1914 it was definitely adopted by Mook.<sup>5</sup> At present *Morosaurus* is considered to be a synonym of *Camarasaurus*, Cope's term having priority and therefore being valid.

*Characters of the Genus Amphicælias.*—*Amphicælias* is more slender than *Camarasaurus*; its remains resemble those of *Diplodocus*, but are somewhat larger than any known *Diplodocus*, and are somewhat more strongly constructed.

#### RESTORATION AND RECONSTRUCTION OF CAMARASAURUS.

*Ryder's Restorations.*—It would be hardly justice to the very able comparative anatomist, Dr. John A. Ryder, to publish, without explanation, his reconstruction (Fig. 1), roughly drawn, life size, and exhibited before The American Philosophical Society December 21, 1877.

The reconstruction was obviously made after one series of bones was exposed, but before Professor Cope had had time to give them much study. It would not appear that Professor Cope himself seriously studied the reconstruction, from the false arrangement of the teeth on the malar jugal arch, and from the placing of consolidated spines like those of the sacrum opposite the massive scapula. Twelve to thirteen vertebræ are consigned to the neck, close to the

<sup>3</sup> "Additional Characters of the Great Herbivorous Dinosaur *Camarasaurus*," Henry Fairfield Osborn, *Bull. Amer. Mus. Nat. Hist.*, Vol. X., Art. xii, June 4, 1898, pp. 219-233.

<sup>4</sup> "The Fore Leg and Pectoral Girdle of *Morosaurus*; with a Note on the Genus *Camarosaurus*," Elmer S. Riggs, *Field Col. Mus. Pub.* 63, *Geol. Ser.*, Vol. I., No. 10, pp. 275-281, Pls. XL., XLI., XLII., October, 1901.

<sup>5</sup> "Notes on *Camarasaurus* Cope," Charles C. Mook, *Ann. New York Acad. Sci.*, Vol. XXIV., pp. 19-22, May 21, 1914, 1 fig.

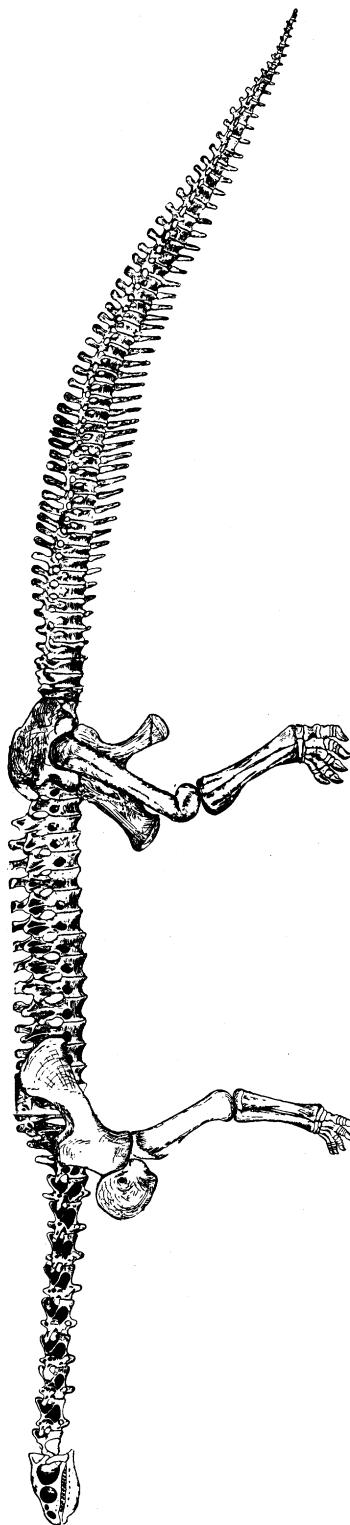


FIG. I. First reconstruction of the skeleton of *Camarasaurus* Cope. This reconstruction was made in 1877 by Dr. John A. Ryder under the direction of Professor E. D. Cope. The original drawing was natural size; it was first exhibited at a meeting of The American Philosophical Society in Philadelphia, Pennsylvania, on December 21, 1877; since that time it has been exhibited at The American Museum of Natural History and elsewhere. It is still preserved in The American Museum as an historic document of great interest. The photograph is about one one-hundredth natural size.

true number. Eighteen vertebræ are consigned to the back, eight too many. Fifty-seven vertebræ are consigned to the tail, not far from the correct number. A complete set of claws is consigned to both the fore and the hind feet.

#### STILL UNKNOWN PARTS OF CAMARASAURUS.

1. In the accompanying restorations and reconstructions of *Camarasaurus* it is observed that our knowledge of this animal is still very incomplete regarding the structure of the pes, the foot bones being based on our knowledge of the pes of *Apatosaurus* or *Brontosaurus*.
2. It is also unknown or uncertain whether these animals possessed a set of abdominal ribs. One rib has been found which may possibly represent a member of the abdominal rib series.

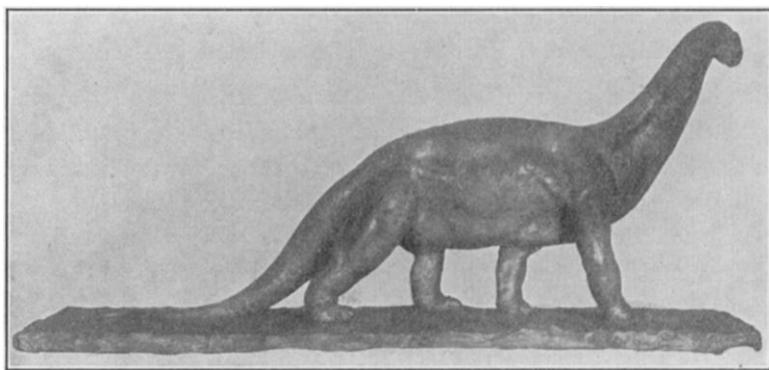


FIG. 2. Restoration of the external appearance of *Camarasaurus*. Photograph of a model of *Camarasaurus* made under the direction of Prof. W. K. Gregory by Mr. E. S. Christman with the coöperation of the authors. This model is the result of very careful comparison of the *Camarasaurus* skeleton with previous sauropod models and with various living reptiles; it embodies extensive myological studies by Professor Gregory, and a thorough analysis of the characters of the skeleton.

3. The vertebral formula is still uncertain, although it is probable that the number was as follows: cervicals 13; rib-bearing dorsals 10, dorsosacral 1; consolidated primary sacrals 3; caudosacral 1; caudals 53.

## PRESENT RECONSTRUCTIONS AND RESTORATIONS.

The accompanying illustrations represent both a *reconstruction* and a *restoration*, based upon the topotype materials of four or more individuals of *Camarasaurus*. The skull characters are partly based upon the *Camarasaurus* topotype skull bones and largely upon the nearly complete skull originally referred to *Morosaurus* by Osborn; it is probable but not certain that this reference is correct.

It is very important to note that the four chief skeletons and two of the remaining skeletons are of approximately the *same linear measurements*, but differ slightly in proportions.

## CHIEF PROPORTIONS OF THE SKELETON.

1. The *enlargement and elevation of the shoulder* above the relatively depressed and reduced sacropelvic region is one of the most surprising features of this reconstruction. This proportion cannot be considered as actually *demonstrated*, because only two complete ilia were found with the four skeletons, and they belong to the same individual. It is possible that these ilia and other bones of the pelvis represent another individual than those individuals represented by the massive scapulocoracoid bones. The other pubes and ischia are of the same size as in the pelvis figured in the restoration.

This makes the highest point in the backbone between the shoulders, as contrasted with the previous restorations of *Brontosaurus* and *Diplodocus* by Osborn, in which the pelvic region is made the high point. Recent studies of *Apatosaurus* by Osborn and Gregory make the shoulders higher than the sacrum.

2. The neck is rather massive and the neck and shoulders bore the chief weight. The heaviest portion of the chest was at the fourth rib, where the relatively immobile hyposphen-hypantrum articulation of the dorsal vertebræ begins.

3. As shown in the articulated skeleton (Fig. 3) the total length and height of the animal, with the spinal curvatures and in the walking pose, were as follows:

Elevation of the head above the ground .....	20 to 22 feet
Total length from the front of the head to the tip of the tail ..	50 to 52 feet
Height of the backbone at the shoulder .....	13 to 14 feet

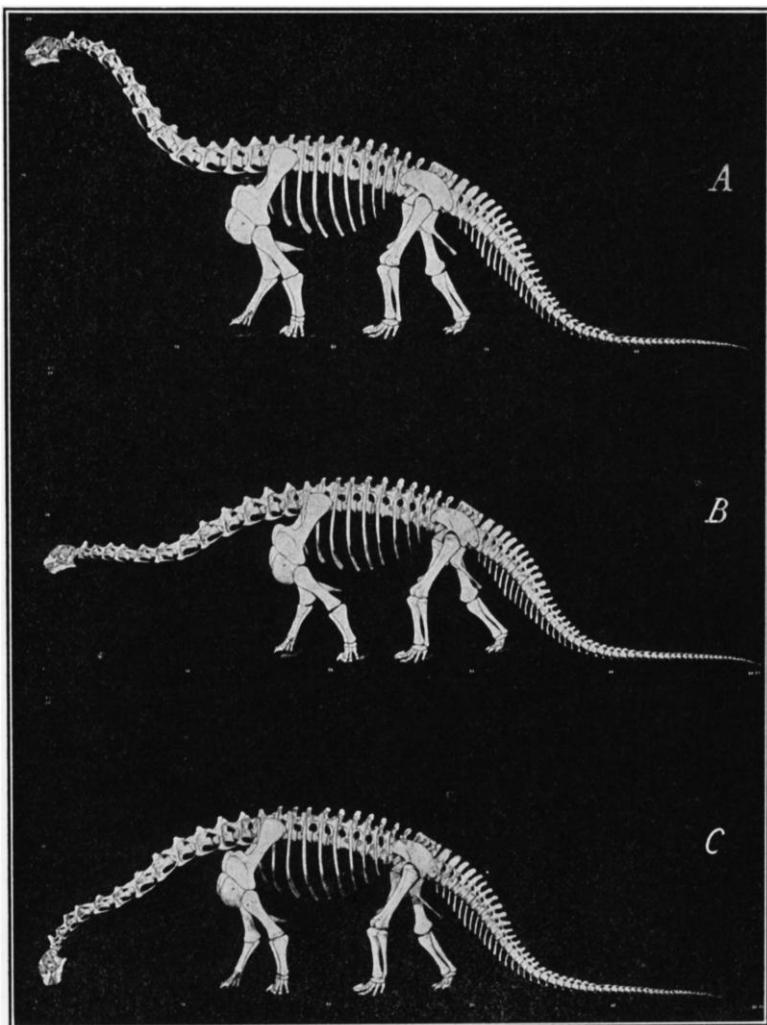


FIG. 3. Three poses of *Camarasaurus*. A, walking pose, head elevated. B, walking pose, head and neck horizontal. C, ground-feeding pose, head depressed. These photographs are made from drawings in which every bone is figured separately to a one-fifth scale and fastened upon a black background. This articulated drawing is successively placed in three poses, A, B and C, each photographed in turn. In the restoration and reconstruction the structure and arrangement of the phalanges of the feet are purely conjectural. The head of the animal attains a height of 20 feet (A). The maximum length in the extended position (B) is 52 feet. Length of backbone, without curvature, between 54 and 55 feet.

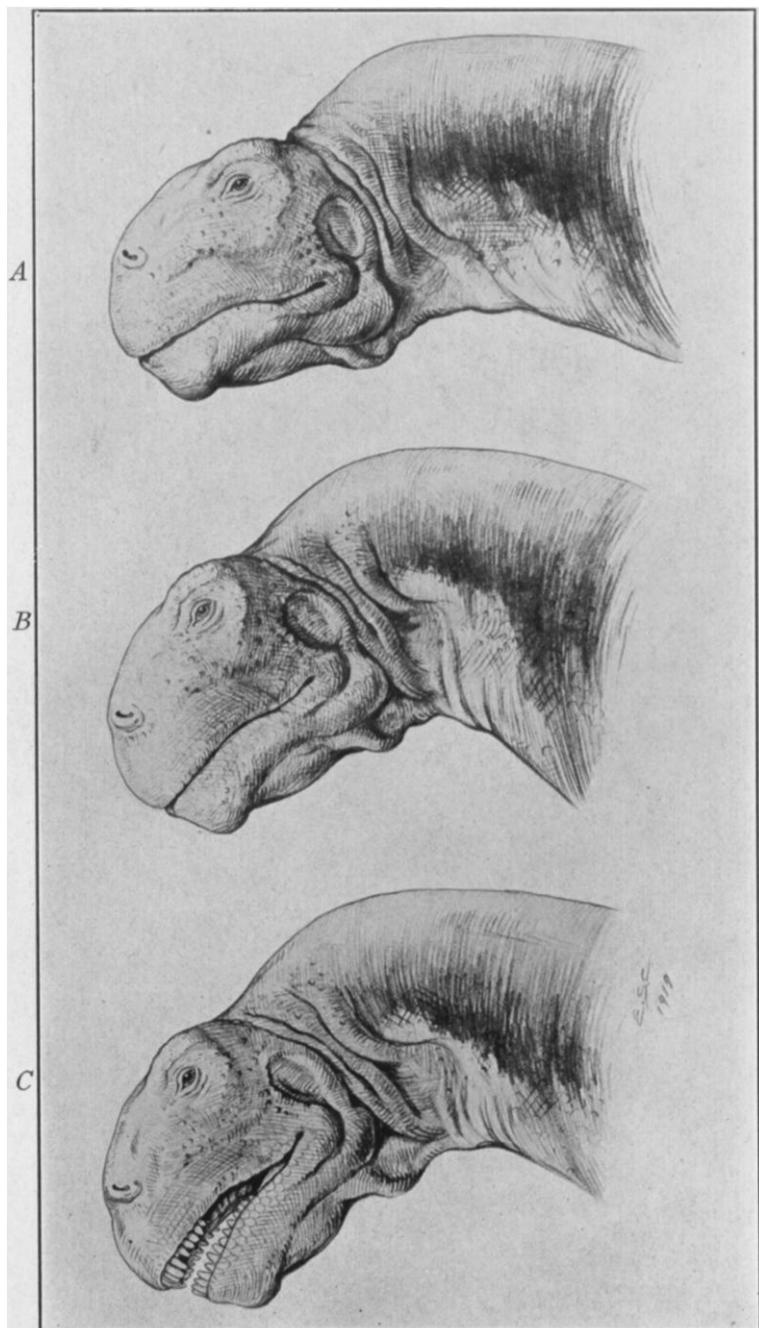
4. The head of the Sauropoda, as pointed out by Dr. W. J. Holland, has been mistakenly represented as parallel with the long axis of the neck, whereas it should be *flexed* or at an angle with the neck. In this respect our restoration gives a somewhat misleading impression, as the head should be bent down as in Pl. I, *B, C*.

#### COMPARISON WITH OTHER SAUROPODA.

As compared with the two other Sauropoda, in which the skeleton is now fully known, namely, *Diplodocus* and *Apatosaurus*, *Camarasaurus* is relatively the most massive, the most elevated at the shoulder, the most elongated over all, and the most ponderous in its proportions. It was apparently not provided with the whip-like terminal tail vertebræ so characteristic of *Apatosaurus* and *Diplodocus*; the vertebræ steadily lessen in longitudinal diameter and would indicate that the tail came to a rather abrupt point.

#### EXTERNAL APPEARANCE OF CAMARASAURUS.

The external appearance of the head is shown in Pl. I. The head is extremely short and deep in its proportions, contrasting with the elongate head of *Diplodocus*. The animal as a whole is sketched in Fig. 2. This represents an animal terrestrial in gait but adapted to an amphibious life, with smooth rounded limbs.



Three studies of head of *Camarasaurus*. A, head extended and bent upwards. B, neck flexed and head bent downwards. C, neck flexed and head bent strongly downwards to show ground-feeding pose and to expose the teeth. The head of *Camarasaurus* is extremely short and deep. The nostrils and eyes are elevated. The tympanum leaves a space behind the quadrates.